1

Hooke's Law (القانون هوك)

Room No: 1A31

Objective- To determine the spring constant ثابت زنبرك (k) by Hooke's law.

Formula used-

Part-1 (Spring Constant by Hooke's law)

Total force on the spring after putting some weight (for table 1)

$$F + F' = 0$$

$$mg - k\Delta L = 0$$

$$mg = k\Delta L$$

$$\Delta L = \frac{g}{k}.m$$

Compare with $y = m\,x$, we get

$$Slope = \frac{g}{k}$$

So, $\boxed{k = \frac{g}{Slope}}$ **for table1**

Where g = 9.8 m/s^2

Observation table-1

m (kg) x 10^{-3} **(x-axis)**	**ΔL increase (m) x 10^{-2}**	**ΔL decrease (m) x 10^{-2}**	**ΔL average (m) x 10^{-2}** **(y-axis)**
50			
100			
150			
200			

Part-2 Spring Constant by time oscillation

When the weight oscillates into the spring, the equation is defined as

$$T = 2® \sqrt{\frac{m + m_0}{k}}$$

$$T^2 = \frac{4®^2}{k}(m + m_0)$$

$$T^2 = \left(\frac{4\pi^2}{k}\right) m + \frac{4\pi^2 m_0}{k}$$

Compare with $y = mx + C$

$$\text{Slope} = \frac{4\pi^2}{k}$$

$$C = \frac{4\pi^2 m_0}{k} \Rightarrow C = Slope \text{ x } m_0 \Rightarrow m_0 = \frac{C}{Slope}$$

Where C is Y-intercept

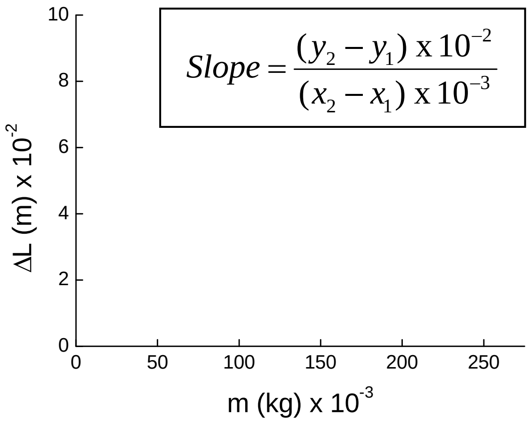
$$\boxed{k = \frac{4\pi^2}{Slope}}$$

for table2

Observation table-2

m (kg) x 10^{-3} **(x-axis)**	**t_1(Sec)**	**t_2 (Sec)**	**t_3 (Sec)**	**t (Sec)**	**T=t/10 (Sec)**	**T^2 (Sec^2) x 10^{-2}** **(y-axis)**
50						
100						
150						
200						

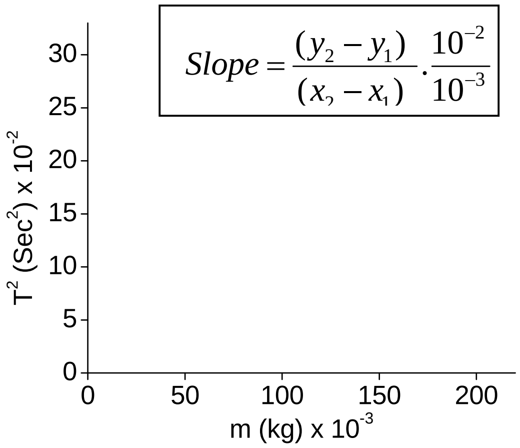
Graph-1



$$Slope = \frac{(y_2 - y_1) \text{ x } 10^{-2}}{(x_2 - x_1) \text{ x } 10^{-3}}$$

$$\boxed{k = \frac{g}{Slope}}$$

Graph-2



$$\boxed{Slope = \frac{(y_2 - y_1)}{(x_2 - x_1)} \cdot \frac{10^{-2}}{10^{-3}}}$$

$$\boxed{k = \frac{4\text{®}^2}{Slope}}$$

Result-1 $k = \dfrac{g}{Slope} = \dfrac{9.8}{(.......)} (N/m)$

Result-2 $k = \dfrac{4\text{®}^2}{Slope} = \dfrac{39.5}{(.......)} (N/m)$

Boyle's Law (القانون بويل)

PHY-103

Room No: 1A20

Objective- To determine the atmospheric pressure (الضغط الجوي) (P_a) by Boyle's law.

Formula used-

$$PV = \text{constant}$$

Where $\text{constant} = (h + P_a).(l.a)$

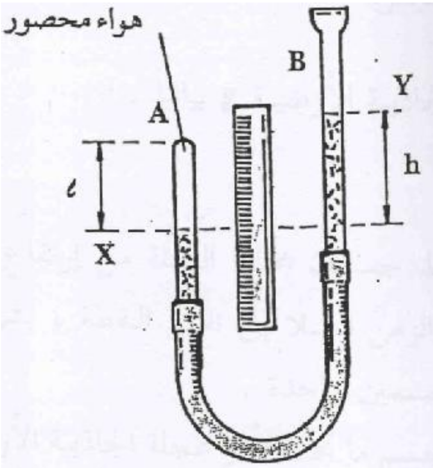
So, $PV = (h + P_a).(l.a)$

$$\frac{1}{l} = (h + P_a).\left(\frac{a}{PV}\right)$$

Say $\left(\frac{a}{PV}\right) = D$

$$\frac{1}{l} = (h + P_a).\,D$$

$D \neq 0$ So, $(h + P_a) = 0 \Rightarrow \boxed{P_a = -h}$



Boyle's experiment

Observation table

$y > x$

A (cm)	x (cm)	y (cm)	$h = (y - x)$ (cm. Hg) **(x-axis)**	$l = (A - x)$ (cm)	$\frac{1}{l}(cm^{-1})$	$\frac{1}{l}(cm^{-1}).10^{-2}$ **(y-axis)**
60						
60						
60						
60						
60						
60						

Graph

x-axis: 1 cm= 2 (cm.Hg)

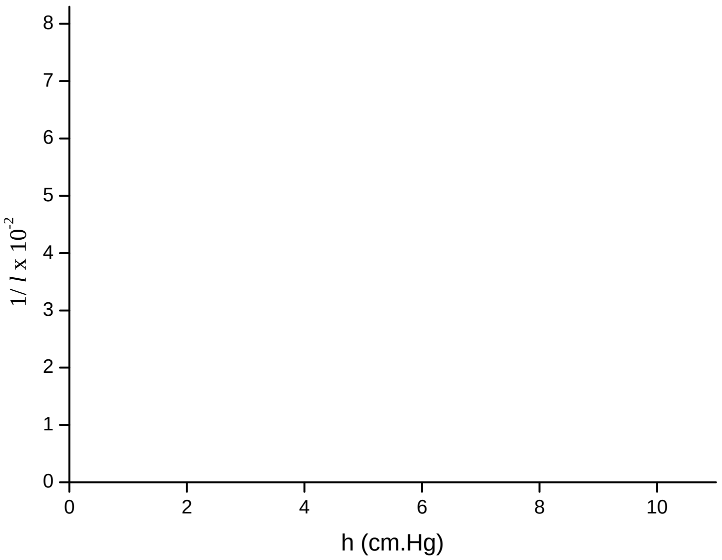
y-axis: 1 cm= 1 x 10^{-2} (cm^{-1})

$$a = slope = \frac{(y_2 - y_1)}{(x_2 - x_1)} \text{ x } 10^{-2} = (......) \text{ x } 10^{-2}$$

$$b = Intercept = (.......) \text{ x } 10^{-2}$$

$$h = -b / a = -(.......)$$

$$Pa = -h = -(-(......)) = (........)\ (cm.Hg)$$



Result: Atmospheric pressure is found to be P_a =.......... (cm.Hg)

Free fall (السـقوط الحـر)

Room No: 1A24

Objective- To determine the acceleration due to gravity تسارع الجاذبية الأرضية (g) by free fall.

Formula used-

Distance travelled by any object in particular time *t* is given by

$$S = ut + 1/2\, g' t^2$$

At start $u = 0 \Rightarrow S = 1/2\, g' t^2$

$$t^2 = \frac{2}{g'} . S$$

Compare with $y = m\,x$, we get

$$Slope = \frac{2}{g'}$$

So, $$\boxed{g' = \frac{2}{Slope}}$$

where,

g = **9.8** m/s^2 (theoretical value of g)

g' = experimental value of g

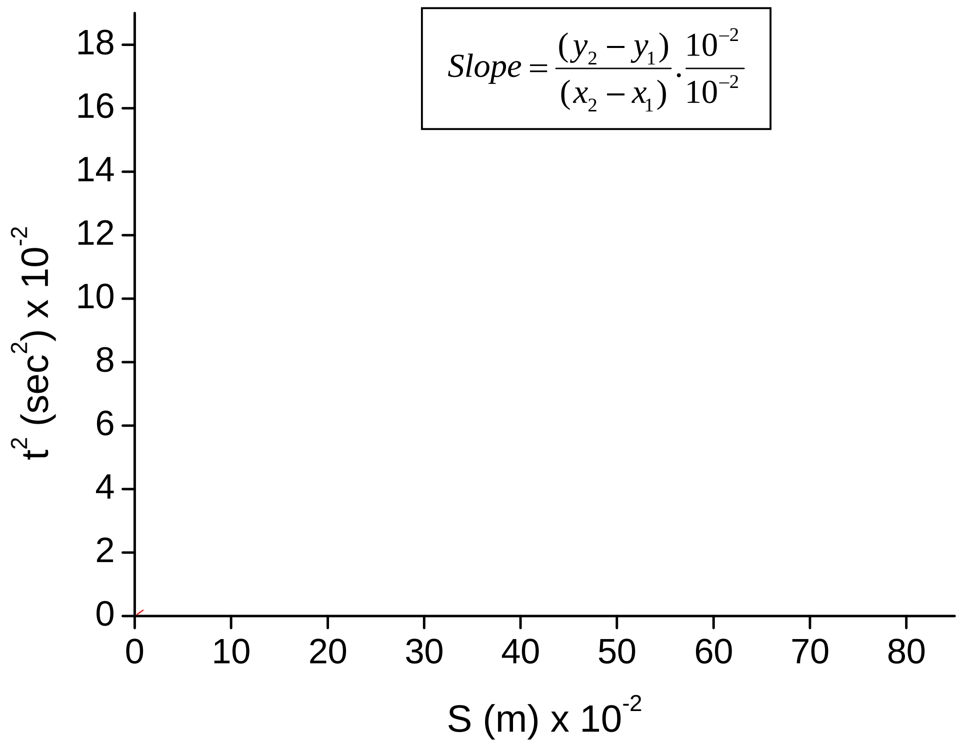
Observation table

S x 10^{-2}(m) **(x-axis)**	**t_1 x10^{-3} (sec)**	**t_2 x10^{-3} (sec)**	**t_3x10^{-3} (sec)**	**t x10^{-3} (sec)**	$\frac{t^2(sec^2)}{10^4}$ **. 10^{-6}. 10^4**	**t^2 (sec^2) x 10^{-2}** **(y-axis)**
80						
70						
60						
50						
40						

Graph

X-axis: 1cm=10 x 10^{-2} (m)

Y-axis: 1cm=2 x 10^{-2} (sec^2)



Result:

$$g' = \frac{2}{Slope} = \frac{2}{(.....)} = ...\,(m/\sec^2)$$

$$\%\,error = \frac{|g - g'|}{g} \text{ x } 100 = \frac{|9.8 - ......|}{9.8} \text{ x } 100 = ...\,\%$$

4

Viscosity (معامل اللزوجة)

Room No: 1A26

Objective- To determine the coefficient of viscosity (η) for pure glycerine by Stokes' law.

Formula used-

Force on the steel balls (downward)

$$F_1 = mg = V\rho g = \frac{4}{3}\pi r^3 \rho_s g$$

Force exerted on ball due to liquid/fluid (upward)

$$F_2 = \frac{4}{3}\pi r^3 \rho_L g$$

Drag force by Stokes' law exerted on the spherical objects in a continuous viscous fluid (upward)

$$F_3 = 6\pi \eta v_t r$$

So, balance the force

$$F_1 = F_2 + F_3$$

$$\frac{4}{3}\pi r^3 \rho_s g = \frac{4}{3}\pi r^3 \rho_L g + 6\pi \eta v_t r$$

$$(\rho_s - \rho_L).g.\frac{4}{3}\pi r^3 = 6\pi \eta v_t r$$

$$v_t = \frac{2}{9}.g\,\frac{(\rho_s - \rho_L)}{\eta}.r^2$$

Compare with $y = m x$, we get

$$slope = \frac{2}{9}.g\,\frac{(\rho_s - \rho_L)}{\eta}$$

So, finally $$\boxed{\eta = \frac{2}{9}.g\,(\rho_s - \rho_L).\frac{1}{slope}}$$

where, g = 9.8 m/s^2

ρ_s = density of solid ball = 7800 kg/m^3

ρ_L = density of liquid glycerine = 1260 kg/m^3

$r = \frac{D}{2}$ = radius of balls

s = distance from 140 – 70 = 70 cm (fixed)

v_t = (s / t) x 10^{-2} (m/s)

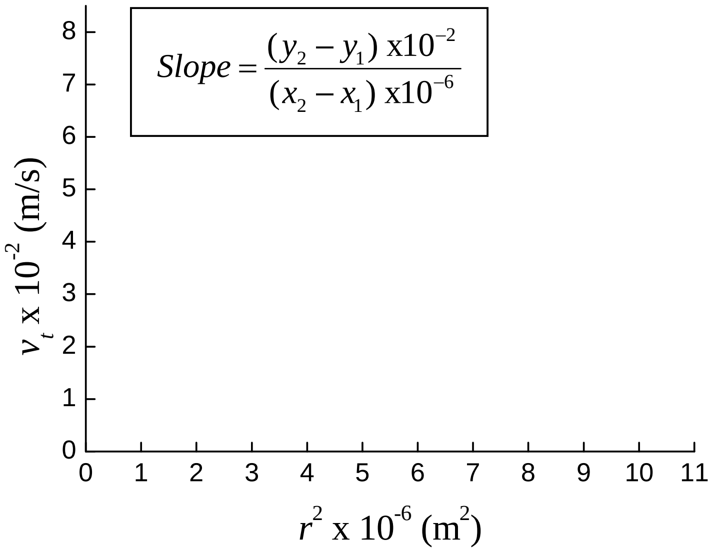
Observation table

D (m) x 10^{-3}	r = D/2 (m) x 10^{-3}	r^2 (m^2) x 10^{-6} **(x-axis)**	t_1 (sec)	t_2 (sec)	t_3 (sec)	t (sec)	v_t = (s/t) x 10^{-2} (m/s) **(y-axis)**
6.34							
4.76							
3.97							
3.17							

Graph

x-axis: 1 cm= 1 x 10^{-6} (m^2)

y-axis: 1 cm= 1 x 10^{-2} (m/s)



Result:

$$\eta' = \frac{2}{9} . g\,(\rho_s - \rho_L) . \frac{1}{slope} \quad = \frac{2}{9} \text{ x } 9.8 \text{ x } (7800 - 1260) \text{x} \frac{1}{(.........)}$$

= .... (Pa.sec)

η = **0.934** Pa.Sec (theoretical value) at 25°C

$$\% \text{ error} = \frac{|\eta - \eta'|}{\eta} \text{x} 100 = \frac{|0.934 - ....|}{0.934} \text{x} 100 = ...\%$$

5

Force table (طاولـة القــوى)

Room No: 1A30

Objective- To compare the resultant angle (θ_R) & resultant force (R) by practical, calculation and graphical methods.

Methods

(i) By practical

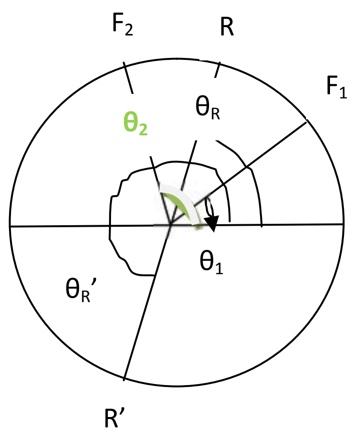
F_1 =........ gwt (say) & θ_1 = ...° (say)

F_2 =........ gwt (say) & θ_2 = ...° (say)

Put the weight F_1 & F_2 and on the other hand put the weight R until it balanced (Note down R). Adjust the ring at the centre that it did not touch anywhere.

R = ... gwt (balance & write)

Calculate $\theta_R = \theta_R' - 180 = ... - 180 = ...^0$



(ii) By calculation

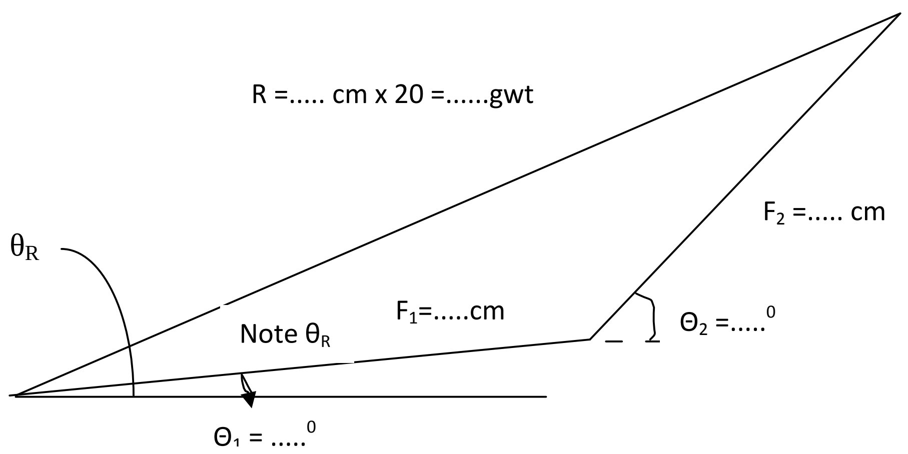
$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos(\theta_2 - \theta_1)} = ...\text{gwt}$$

$$\theta_R = \cos^{-1}\left(\frac{F_1\cos\theta_1 + F_2\cos\theta_2}{R}\right) = ...^0$$

(iii) By graphical

1 cm = 20 gwt => 1 gwt = 1/20 cm

F_1 = ... gwt = .../20 =..... cm at θ_1 = ...°
F_2 = ... gwt = .../20 =..... cm at θ_2 = ...°



Calculate R = 20 x ....= .... gwt

θ_R = (........)^0

Results

(Comparison table)

Method	θ_R (degree)	R (gwt)
Practical		
Calculation		
Graphical		

6

Young's Modulus (معامل يونج)

Room No: 1A10

Objective- To determine the Young's modulus (Y) of given wire.

Formula used-

Young's modulus (modulus of elasticity) is a measure of the stiffness of an elastic material and given by the following equation

$$Y = \frac{Stress}{Strain} = \frac{F / A_0}{\Delta L / l_0} = \frac{M.g / \text{®}\, r^2}{\Delta L / l_0}$$

$$Y = \frac{g\, l_0}{\text{®}\, r^2} . \frac{1}{(\Delta L / M)}$$

$$\Delta L = \frac{g\, l_0}{\text{®}\, r^2 Y} . M$$

Compare with $y = m\,x$, we get

$$slope = \frac{g\, l_0}{\text{®}\, r^2 Y}$$

So, finally we get

$$\boxed{Y = \frac{g\, l_0}{\text{®}\, r^2} . \frac{1}{slope}}$$

where

g = acceleration due to gravity = **9.8** m/s^2

r = radius of wire = **0.73/2** mm = **0.36 x 10^{-3}** (m)

l_0 = original length of wire (in meter) =........x 10^{-2} (m)

Note: Assume hanger weight to zero. Make a zero by rotating yellow scale.

1 mm = 10^{-3} m

0.01 mm = 10^{-5} m

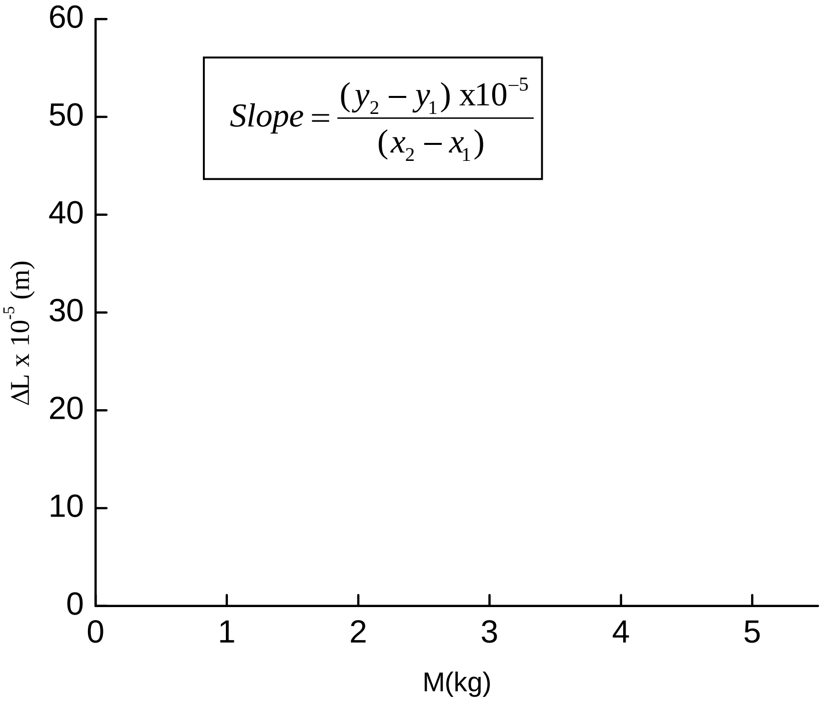
Observation table

M (kg) (x-axis)	ΔL_1 x $10^{-5}(m)$ (increment)	ΔL_2 x $10^{-5}(m)$ (decrement)	ΔL x $10^{-5}(m)$ (average) (y-axis)
1			
2			
3			
4			
5			

Graph

x-axis: 1 cm= 1 (kg)

y-axis: 1 cm= 10 x 10^{-5}(m)



Note: take those points for slope which are not in the table.

Result: $Y = \frac{g\ l_0}{\text{®}\ r^2} \cdot \frac{1}{slope} = \frac{9.8\ \text{x ...... x}\ 10^{-2}}{3.14\ \text{x}\ (0.36\ \text{x}\ 10^{-3})^2} \cdot \frac{1}{(..........)} = ...(N/m^2)$

Aircraft (هوائي العربة)

Room No: 1A1

Objective- To compare the Kinetic Energy (K.E.) and Potential Energy (P.E.) by aircraft.

Formula used-

(P.E.)	**W = m.g.s**
(K.E.)	**K = ½ M v^2**
	v = 2s / t

Where,

M = mass of aircraft (written on each machine) = ... gm (say)
m = suspended mass
s = distance travelled by aircraft = (1 m approx)
v = velocity of aircraft

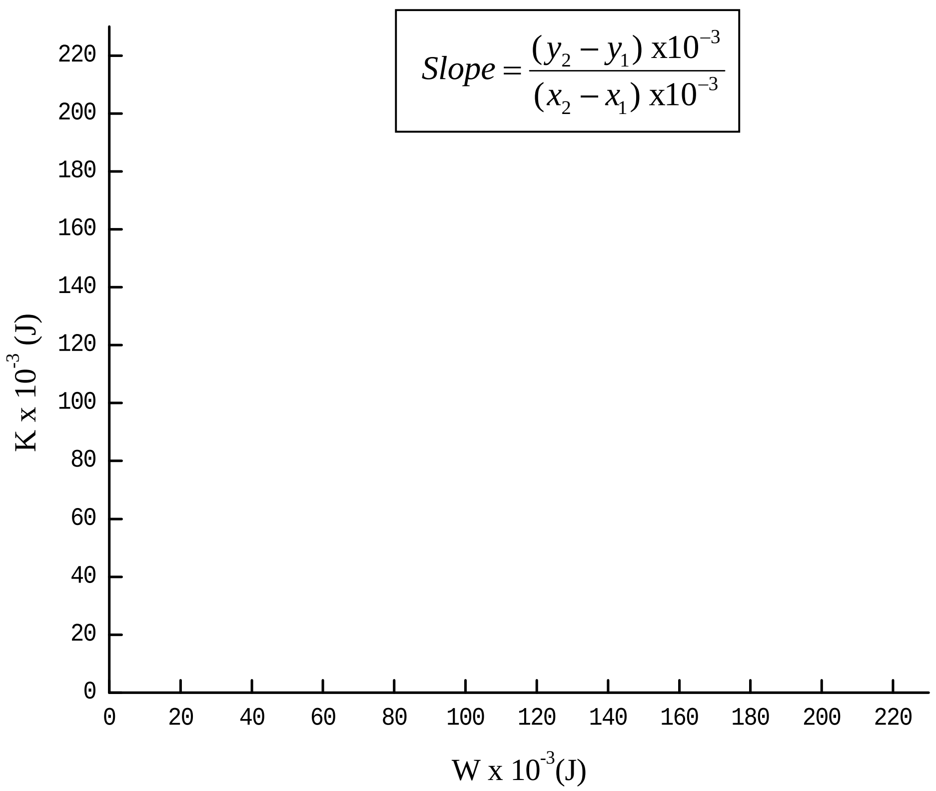
Observation table

m (kg) x 10^{-3}	**P. E.** الطاقة الكامنة **W= m.g.s x 10^{-3} (J)** **(x-axis)**	t_1 **(sec)**	t_2 **(sec)**	t **(sec) average**	$v = \frac{2s}{t} (m/s)$	$K = \frac{1}{2} M v^2$ x 10^{-3} (J) الطاقة الحركية **(y-axis)**
5						
10						
15						
20						
25						

Graph

x-axis: 1cm=20 x 10^{-3}(J)

y-axis: 1cm=20 x 10^{-3}(J)



Result:

Percentage ratio in lost energy = (1 – slope) x 100

= (1 – ....) x 100

= .... %

Specific heat (حرارة نوعية)

Room No: 1A3

Objective- To determine the specific heat of given ball.

Formula used-

Amount of heat added or removed from the system is defined as

$$Q = m\,C\,\Delta t$$

On balance position

$$\mathrm{Q_b} = \mathrm{Q_c} + \mathrm{Q_w}$$

$$m_b\,C_b(T_2 - T) = (m_c C_c + m_w C_w)\,(T - T_1)$$

Specific heat of ball can be find as

$$C_b = \frac{(m_c C_c + m_w C_w)\,(T - T_1)}{m_b(T_2 - T)}$$

where, m_c = mass of calorimeter = ... x 10^{-3} (kg)

C_c = specific heat of calorimeter = **908** J/kg.K

m_{cw} = mass of calorimeter with water = ... x 10^{-3} (kg)

m_w = mass of water = ($m_{cw} - m_c$) = ... x 10^{-3} (kg)

C_w= specific heat of water = **4182** J/kg.K

m_b = mass of ball = ... x 10^{-3} (kg)

T_1 = initial temperature of normal water (.......°C + 273 = ...K)

T_2 = final temperature of hot water (......°C + 273 = ...K)

T = equilibrium temperature = (.......°C + 273 = ...K)

Method

1. Weight the calorimeter without water
2. Weight the calorimeter with water
3. Find m_w
4. Put the digital thermometer in normal water & note down T_1.
5. Hot the calorimeter with water upto T_2 & calculate T (stir the water continuously).
6. Then find C_b by above formula.

Result: substitute all the values in above equation, we get

C_b' =........... J/kg.K

C_b = **380** J/kg.K (theoretical value)

$$\%\ error = \frac{|C_b - C_b'|}{C_b}\,\mathrm{x}\,100 = \frac{|380 - ....|}{380}\,\mathrm{x}\,100 = ...\%$$

Joule’s Equivalent (مكافئ الجول)

Room No: 1A5

Objective- To determine the Joule’s equivalent of water.

Formula used-

Joule’s equivalent is defined as

$$J = \frac{\text{Work done}}{\text{Dissipated heat}} = \frac{W}{H} = \frac{I^2 R\ t}{(H_w + H_c + H_s)} = \frac{I\ V\ t}{(H_w + H_c + H_s)}$$

because V = IR by Ohm’s law.

$$J = \frac{I.V.t}{(M_w C_w + M_{oc} + M_{os})\,(T_2 - T_1)}$$

where,

V = voltage = ... volts

I = current =....... A

t = time = ... min = ...x 60 sec = ...sec

M_c = mass of calorimeter without water =........ g

M_{cw} = mass of calorimeter with water =.......... g

M_w = mass of water = $(M_{cw} – M_c)$ = ... g

C_w = specific heat of water = **1** Cal/g.°C

M_{oc}= water equivalent of calorimeter = **24** Cal/°C

M_{os}= water equivalent of stirrer & coil = **3.6** Cal/°C

T_1 = initial temperature of normal water = (........°C)

T_2 = final temperature of hot water (T_1 + 5 = ...°C)

Method

1. Weight the calorimeter without water
2. Weight the calorimeter with water
3. Find M_w
4. Put the digital thermometer in normal water & note down T_1.
5. Hot the calorimeter with water upto T_2 & calculate T (stir the water continuously).
6. Then find J by above formula.

Result: substitute all the values in above equation, we get

J ’=........ J/Cal

J = **4.18** J/Cal (theoretical value)

$$\% \text{ error} = \frac{|J-J'|}{J} \text{x}100 = \frac{|4.18-.......|}{4.18} \text{x}100 = ...\%$$

10

Speed of sound (سرعة الصوت)

Room No: 1A16

Objective- To determine the speed of sound at room temperature.

Formula used-

Speed of sound at temperature *t* for node L = λ/4

$$v_t = f.\text{ª} = f.4L = f.4(l+0.6r)$$

$$\frac{v_t}{4}.\frac{1}{f} = l + 0.6r$$

$$l = \frac{v_t}{4}.\frac{1}{f} - 0.6r$$

Compare with $y = mx + c$, we get

$$slope = \frac{v_t}{4} \Rightarrow \quad \boxed{v_t = 4 \text{ x slope}}$$

We know, speed of sound at temperature *t*

$$\boxed{v_t = v_0 + 0.6t}$$

Known parameter

t = 23°C (room temperature)

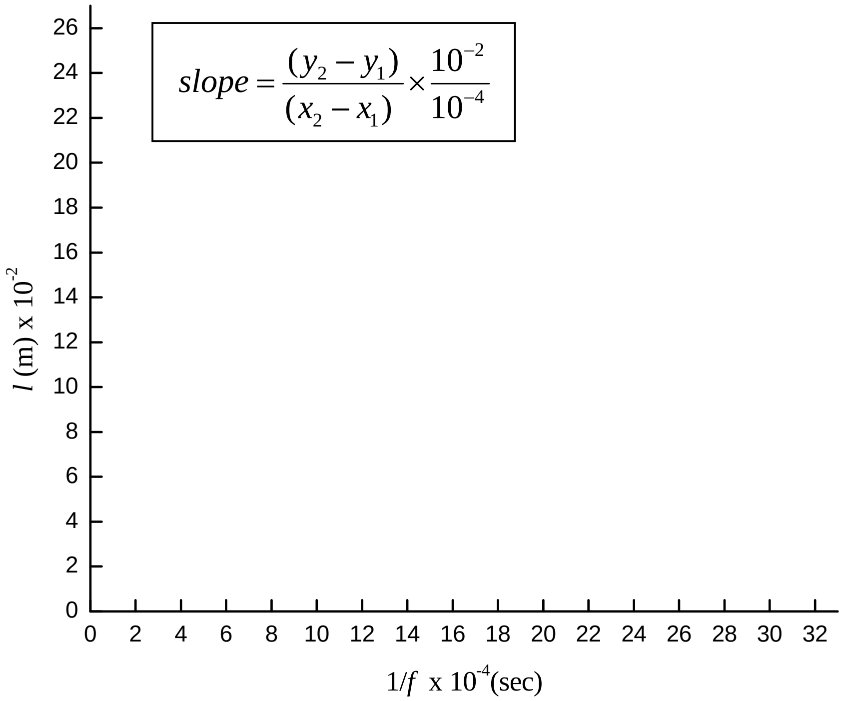
Observation table

f (Hz) (known)	1/*f* (sec) x 10^{-4} (x-axis)	*l* (m) x10^{-2} (y-axis)
512		
480		
426.7		
384		
320		

Graph

x-axis: 1 cm= 2 x 10^{-4}(sec)

y-axis: 1 cm= 2 x 10^{-2}(m)



Note: take those points for slope which are not in the table.

Method

Immerse the pipe in water completely and at the same time put the fork to the open side then slowly move the pipe to upward direction and stop the pipe where sound appears maximum & note down the distance *l*.

Result:

$v_t' = 4$ x slope = 4 x .... =........ (m/sec)

Take v_0 = **331** m/s (We know)

$v_t = v_0 + 0.6t$ = 331 + (0.6 x 23) = 334.8 (m/sec) (theoretical value)

$$\% \text{ error} = \frac{|v_t - v_t'|}{v_t} x100 = \frac{|334.8 - ....|}{334.8} x100 = ...\%$$